

eGSE America: Electric Aircraft PushBack Tractor (EAPT) Technical Specifications

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1.0 SCOPE:

This document outlines the design and performance requirements specifically for the propulsion and energy management systems of a battery-powered electric aircraft pushback tractor (hereafter “tractor”). This document shall apply to both a “Towbar” and “Towbarless” type of pushback tractor. The use of “shall” in this document indicates a mandatory requirement. The use of “should” indicates a recommendation or that which is advised but not required.

2.0 APPLICABLE DOCUMENTS:

Portions of the following documents to the extent specified herein are a part of this Recommended Practice.

ASME/ANSI B56.9-1992 (Reaffirmed 2000)	Safety Standard for Operator Controlled Industrial Tow Tractors
ANSI/NEMA No. 250-1997 (AUG01)	Enclosures for Electrical Equipment (1000 Volts Maximum)
BCI Technical Manual 2 nd Edition	Battery Technical Manual, Second Edition, Pages 39 through 41
CiA Draft Standard Proposal 418 (OCT02)	CANOpen: Device Profile for Battery Modules
CiA Draft Standard Proposal 419 (JAN03)	CANOpen: Device Profile for Battery Charger
IWC Report Final Draft (APR02)	National Infrastructure Working Council (IWC) Non-road Fast Charging & Connectors Sub-Committee Report: <u>Electric Ground Equipment Conductive Fast Charge Specification</u>
MIL-STD-461E (AUG99)	Electromagnetic Interference Characteristic Requirements for Equipment
NFPA No. 505 (AUG02)	Standard for Use, Maintenance and Operation of Industrial Trucks. Fire Safety for Powered Industrial Trucks
SAE ARP1247 Rev. C (DEC98)	General Requirements for Aerospace Powered Mobile Ground Support Equipment
SAE AIR 1375 (JUN00)	Minimum Safety Requirements for Special Purpose Airline Ground Support Equipment
SAE ARP1817 Rev. A (MAR98)	Batteries for Battery Powered Ground Support Equipment
SAE AS4828 (JUN02)	Technical Manual Development for Ground Support Equipment

SAE ARP4852 REV.B (NOV00)	Design Specifications for Towbarless Push-Back Tow Vehicles
SAE J163 (JAN01)	Low Tension Wiring and Cable Terminals and Splice Clips
SAE J377 (FEB87)	Performance of Vehicles Traffic Horns
SAE J551-1 (JUN96)	Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles and Devices (60 HZ to 18 GHZ)
SAE J551-12 (SEP96)	Vehicle Electromagnetic Immunity – On-board Transmitter Simulation
SAE J561 (JUN93)	Electrical Terminals – Eyelet and Spade Type
SAE J858a (AUG69)	Electrical Terminals Blade Type
SAE J1127 (MAY00)	Battery Cable
SAE J1128 (MAY00)	Low Tension Cable
SAE J1654 (MAY00)	High Voltage Cable
SAE J1673 (JUL96)	High Voltage Automotive Wiring Assembly Design
SAE J1690 (AUG96)	Flashers
SAE J1742 (MAR98)	Connections for High Voltage On-Board Road Vehicle Electrical Wiring Harnesses Test Methods and General Performance Requirements
UL 583 (9 th Edition, JUN96) (Including Revisions through JUL99)	Electric-Battery-Powered Industrial Trucks

3.0 DESIGN REQUIREMENTS

3.1 General Requirements

- 3.1.1 The tractor shall comply with all performance requirements over the full range of environmental factors specified in SAE ARP 1247, Paragraph 3.6.

- 3.1.2 The tractor should comply with the requirements of NFPA 505 and UL 583 for Type E, ES, EE or EX vehicles. Manufacturer shall specify whether the tractor meets the requirements of Type E, ES, EE or EX.
- 3.1.3 The manufacturer shall list and describe in detail specifically which aircraft the tractor will adequately service while meeting the requirements found herein.
- 3.1.4 The tractor should comply with SAE ARP 4852 where applicable.

3.2 Electrical System

The electrical system shall consist of an appropriate size and type traction battery pack powering a compatible electric motor(s) through an electronic controller(s) to produce smooth acceleration and operation. Traction battery voltage should reflect the best design for duty cycle, vehicle speed, tractive effort and minimum current losses. The traction battery charger shall be appropriately selected to properly charge the traction battery and meet the requirements of the particular application.

3.2.1 Traction Battery

- 3.2.1.1 The traction battery should comply with the requirements of SAE ARP1817. Battery rating and testing by the manufacturer shall follow the requirements of the BCI Battery Technical Manual. The battery provided shall be of size and capacity to satisfy performance and accessory requirements. Operational characteristics should also be considered when selecting the proper battery, such as the average amp-hour draw, any non-gassing requirements, available maintenance personnel and facilities. The vehicle manufacturer shall provide the battery manufacturers specifications including the one hour, three hour, and five hour discharge rating of the traction battery (in ampere-hours) and shall specify the battery discharge rate (in amperes) when operating under a load as defined by:

$$\text{Load} = .8 * \frac{(\text{Maximum Dynamic Draw Bar}_{(100\% \text{ Battery SOC})} + \text{Maximum Dynamic Draw Bar}_{(50\% \text{ Battery SOC})})}{2}$$

- 3.2.1.2 Means of restraining the traction battery in the lateral and longitudinal directions shall be provided.
- 3.2.1.3 Vehicle manufacturer should supply battery manufacturers recommended traction battery charging algorithm.
- 3.2.1.4 Vehicle Manufacturer should supply traction battery maintenance requirements.
- 3.2.1.5 Vehicle Manufacturer shall indicate the depth of discharge below which the traction battery should not be discharged.
- 3.2.1.6 The traction battery shall be protected by a cover, which shall support at least 12 lbs/sqft.
- 3.2.1.7 The traction battery and traction battery compartment shall be designed such that electrolyte from the battery is captured in an auxiliary tray or the battery tray and not allowed to drain onto the ground, corrode parts of the tractor, or create acid paths for current to flow to the chassis. This requirement does not apply when sealed batteries are used.
- 3.2.1.8 Battery cable connectors shall be located such that they create no danger of igniting gases expelled during battery charging. The location should also be convenient for charging while not subject to damage during battery removal or installation.

- 3.2.1.9 Manufacturer shall supply an MSDS for the battery and any materials used in the tractor that would not typically be found in an automotive shop.
- 3.2.1.10 Manufacturer shall specify recommended and maximum allowable battery weight (full rated load).
- 3.2.1.11 Beginning at full charge, vehicles should be capable of operating and charging after being out of service in an ambient temperature between 40°F and 120°F and off charge for 16 days. No operator action should be required during this period.
- 3.2.2 Propulsion System
 - 3.2.2.1 The electronic controller(s) and motor(s) shall be sized for the application and shall limit maximum battery discharge as specified in Section 3.2.1.5 to prevent degradation of battery life and abrupt loss of tractor operability. Such limit shall be adjustable, repeatable, and accurate within 10% battery state of charge.
 - 3.2.2.2 All wiring and components used in the high voltage propulsion system shall be of a “two-wire” design using an insulated return wire rather than the vehicle chassis as ground and sized in compliance with SAE J1673.
 - 3.2.2.3 Vehicles shall not contain exposed conductors, terminals, contact blocks or devices of any type that create the potential for personnel to be exposed to 60 volts (nominal battery voltage) or greater (the distinction between low voltage and HIGH VOLTAGE, as specified in SAE J1127). Access to any HIGH VOLTAGE components shall require the removal of at least one bolt, screw, cover, or latch. Devices considered to be HIGH VOLTAGE components shall be clearly marked as “HIGH VOLTAGE.” These markings should be installed at any point the voltage can be accessed by the end user. HIGH VOLTAGE cable and wire marking shall consist of orange wire and/or orange sleeves as required by SAE-J1127.
 - 3.2.2.4 All HIGH VOLTAGE cable shall comply with the requirements of SAE-J1654. All battery voltage cable shall comply with the requirements of SAE-J1127.
 - 3.2.2.5 HIGH VOLTAGE connectors (except charger power supply to vehicle) should utilize latching devices to prevent inadvertent disconnection, shall be keyed to prevent mis-connection and should be moisture proof. HIGH VOLTAGE connectors should comply with the requirements of SAE-J1742.
 - 3.2.2.6 The tractor should utilize a single speed, multi-speed automatic, hydrostatic or continuously variable transmission.
 - 3.2.2.7 A propulsion power system operating at greater than 60 volts shall be isolated from the vehicle chassis such that leakage current does not exceed 20mA with the battery connected.
 - 3.2.2.8 An arrangement for the controller to provide regenerative braking should be offered. Maximum regenerative braking settings shall be adjustable such that maximum current returning to the traction battery pack can be set to avoid potential damage to traction battery pack or electrical components.
 - 3.2.2.9 Regenerative braking shall not adversely impact the tractor's braking stability, particularly on varying road surfaces.
 - 3.2.2.10 If a traction motor with armature brushes used, the motor should be easily accessible for brush inspection.

3.2.3 Accessory Power System

- 3.2.3.1 Accessory power system shall be used to power the following;
- a. Two sealed beam headlights on front of tractor (one each side),
 - b. Two tail lights on rear of tractor (one each side),
 - c. Two brake lights on rear of tractor (one each side),
 - d. Two back-up lights on rear of tractor,
 - e. Emergency flashers, and
 - f. Floodlight for front and rear hitches or pickup device.

A combination assembly may be used to accommodate the brake and tail lights. A horn shall be supplied and should comply with the requirements of SAE J377.

- 3.2.3.2 The accessory power system should incorporate a “2-wire” design using an insulated return wire rather than the vehicle chassis as ground for isolation purposes. If chassis ground is used for the accessory power negative it shall be isolated from the traction system by at least 500,000 ohms resistance. The accessory power system shall be supplied from the main traction battery by an electronic DC-to-DC converter.

- 3.2.3.3 Low voltage connectors should comply with the applicable requirements of SAE J163, J561, and J858.

- 3.2.3.4 Low voltage wire shall meet the requirements of SAE J1128.

- 3.2.3.5 All electronic components shall be protected by an enclosure meeting the requirements of ANSI/NEMA 250-1997, Type 4 Enclosure.

- 3.2.3.6 The electrical/electronic systems shall incorporate proper shielding and filtering, to assure electromagnetic compatibility of the vehicle with any and all communication and navigation frequencies in and around the airport ramp areas in accordance with MIL-STD-461. The tractor shall not be susceptible to externally generated electromagnetic fields and shall comply with the applicable sections of SAE J551-1. Additionally, vehicles shall not be susceptible to electric magnetic fields from an on-board radio transmitter and shall comply with the requirements of SAE J551-12.

3.2.4 Battery Charging

- 3.2.4.1 It shall not be possible to drive the tractor when the tractor is connected to the charger.

- 3.2.4.2 Charging circuits shall be isolated from the vehicle chassis such that ground current from the grounded chassis does not exceed 20 mA at any time the vehicle is connected to an off-board charger.

- 3.2.4.3 Charge connector shall be prevented from being inadvertently connected to the controller or motor rather than the battery.

3.2.5 Electrical Systems

- 3.2.5.1 Electric Systems shall comply with the requirements of SAE ARP1247 Paragraphs 3.13.1.2.5, 3.13.1.2.6, 3.13.1.2.9, 3.13.1.2.10, 3.13.1.2.12, 3.13.1.2.20, and 3.13.1.2.23.

4.0 PERFORMANCE REQUIREMENTS:

- 4.1 The following performance requirements apply to dry level concrete (co-efficient of friction of 0.7 or better), with an outdoor ambient and traction battery temperature of 77°F (25°C), unless otherwise specified.

- 4.2 The manufacturer shall report the maximum static drawbar pull, with the traction battery at 100% and at 50% (+/- 10%) state of charge.
- 4.3 The maximum tractor speed with no towed load shall be a minimum of 12 mile per hour and the maximum tractor speed shall be settable by a controlled method.
- 4.4 The manufacturer shall report the maximum draw bar of the tractor at a speed of 4.0 miles per hour (6.0 kilometers per hour) with the traction battery at 100% and at 50% (+/- 10%) state of charge.
- 4.5 At the maximum drawbar stated in 4.4, the controller, motor and battery shall be capable of continuous operation at 4.0 mph (6.0 kilometers per hour) for at least three minutes without overheating or damage to the propulsion system.
- 5.0 OPERATOR CONSIDERATIONS:
- 5.1 Instruments
- 5.1.1 Dash instrumentation should include a state of charge indicator for the propulsion battery. Indications should be repeatable and accurate to +/- 10% of full scale.
- 5.1.2 Dash instrumentation shall include an hourmeter and an indicator light to warn the operator of a brake failure.
- 5.2 Safety Requirements
- 5.2.1 The Tractor requirements shall comply with the requirements of SAE ARP 1247, Paragraphs 3.8, 3.9 and 3.10, SAE AIR 1375 and ANSI B56.9-1992.
- 5.2.2 A deadman type seat switch shall be supplied with an interlock that de-activates the traction circuit whenever the operator is not on the seat. The switch and its installation shall be designed to prevent false tripping due to driving over bumps or the operator leaning in any direction on the seat.
- 5.2.3 The controller shall incorporate a "static return to off" feature. This requires the operator to set the directional control to neutral before tractor movement is possible once the seat switch has been opened.
- 5.2.4 A handbrake interlock shall also be provided to prevent traction system operation unless the handbrake is disengaged.
- 5.2.5 Vehicles using HIGH VOLTAGE traction systems shall be equipped with a "master" switch that shall interlock controller propulsion functions and battery contactor(s), if any, to render the propulsion system inoperative. Contactors(s) used in conjunction with the master switch shall be capable of interrupting maximum rated controller/inverter current.
- A manual service disconnect for vehicles using a HIGH VOLTAGE traction system shall also be required. It shall have the following characteristics:
- Manual action is required to break the connection,
 - The disconnection is physically verifiable,
 - The disconnection does not create exposed conductors capable of becoming energized while exposed, and
 - The service disconnect is clearly marked and is accessible without the use of tools.
- 5.2.6 The tractor should be designed for easy access to those areas that require frequent checks and/or servicing.

5.2.7 Information regarding maximum towing speed shall be properly placarded on the dash and at the tow points if potential damage exists to the traction motor during maintenance towing at higher than recommended speeds.

6.0 MAINTENANCE REQUIREMENTS:

6.1 Requirements of SAE ARP1247, Paragraph 3.12.5 shall be followed where applicable. Systems and components requiring expertise not normally found with ground equipment mechanics shall have adequate troubleshooting charts and procedures. Simplified and/or automatic test equipment is encouraged.

6.2 The tractor shall be supplied with a service manual that includes the traction system, and which complies with the requirements of SAE AS4828.

6.2.1 The manual shall include a complete electrical schematic, wiring diagram and component location chart.

6.2.2 Instructions for removing the battery pack shall be adequately illustrated in the manual.

6.2.3 Any special tools or test equipment shall be identified in the manual and drawings or source of procurement documented.

7.0 OPTIONS:

7.1 Optional Cab accessories should include a windshield wiper, window heater/defroster, dome light, hazard light, turn signals, and provisions for a ramp two-way radio

7.2 An indicator light on the dash to caution the operator of motor brush wear should be offered where applicable.

7.3 Cold weather option for the battery should be offered.

7.4 Hazard lights should be offered which are capable of at least one hour of continuous operation in the event of shutdown or isolation of the propulsion battery pack or failure of the DC/DC converter system as required by SAE J1690.

7.5 Universal chargers which communicate with the vehicle battery pack and capable of automatically charging a wide range of battery packs should be offered.

7.5.1 A vehicle charge receptacle meeting the requirements of the IWC Electric Ground Equipment Conductive Fast Charge Specification should be offered.

7.5.2 The vehicle should incorporate a method to ensure that accessible receptacle high-voltage pins are not energized when exposed to human contact and during normal vehicle operation, and the vehicle shall be immobilized to prevent a "drive-off" scenario when the charge plug is engaged in the vehicle receptacle.

7.5.3 The charge receptacle should be located on the vehicle in such a way as to minimize incidental connector "snags" after the operator removes the charge connector from the vehicle charge receptacle.

7.5.4 The battery to charger communications module should comply with the requirements of "CiA Draft Standard Proposal 418."

- 7.5.5 The vehicle-charger communication protocol should meet the requirements of “CiA Work Draft Proposal 419.”
- 7.5.6 The charger should be capable of returning the battery from the maximum depth of discharge specified in Section 3.2.1.5 to 80% state of charge in less than 2 hours.